COMPARATIVE EVALUATION OF PENETRATION DEPTH AND PUSH-OUT BOND STRENGTH OF C POINTS & GUTTA PERCHA USING BIOCERAMIC & AH PLUS SEALER – AN INVITRO STUDY.

Dissertation submitted to

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In partial fulfillment for the degree of

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BRANCH – IV

CONSERVATIVE DENTISTRY AND ENDODONTICS

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ENDORSEMENT BY THE H.O.D. PRINCIPAL / THE HEAD OF THE INSTITUTION

This is to certify that **Dr. M. LOGANATHAN,** Post Graduate student (2015–2018) in the Department of Conservative Dentistry and Endodontics, K.S.R. Institute of Dental Science and Research, has done this dissertation titled **"COMPARATIVE EVALUATION OF PENETRATION DEPTH AND PUSH-OUT BOND STRENGTH OF C POINTS & GUTTA PERCHA USING BIOCERAMIC & AH PLUS SEALER – AN INVITRO STUDY"** under our guidance and supervision in partial fulfillment of the regulations laid down by **TheTamil Nadu Dr. M.G.R. Medical University**, Chennai – 600 032 for **M.D.S.,** (Branch – IV) **CONSERVATIVE DENTISTRY AND ENDODONTICS** degree examination.

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INTRODUCTION

The main goal of endodontic treatment is to remove the diseased tissues, to eliminate the bacteria from the root canal system & to neutralize any agents that may be left in the canal & to prevent its reinfection[1]. The three dimensional (3D) obturation is the primary objective of root canal therapy to seal all "portals of exit"[2]. Obturation of a root canal is a combination of central core material and sealer cements to fill the voids. The core materials exerts pressure against the walls leading to increased interaction between sealer & root dentin.[3]

Among the core materials, Gutta Percha is the most popular & standard core material used for obturation. Even though Gutta Percha has achieved certain properties of root canal filling material, it has certain drawbacks – its inability to bond to the canal wall due to its hydrophobic nature & shrinkage on application of heat resulting in microleakage[4].

In the wake of this concept, in order to ameliorate the bonding of the materials to the root canal wall and to negate the application of heat , materials having hydrophilic properties were introduced . The most recent advancement in endodontic obturating materials utilizes a hydrophilic polymer in the root canal, the C Point system (Endotechnologies, LLC). The endodontic points are designed to expand laterally without expanding axially by absorbing residual dihydrogen monoxide from the instrumented root canal space and the naturally present moisture in the dentinal tubules[5].

Endodontic sealers play an important role by improving the adaptation of root filling at the dentin-material interface[6]. The sealers can fill the irregularities of the root canal & dentinal tubules, which cannot be filled by GP[7].

AH Plus (Dentsply DeTrey, Konstanz, Germany) is an epoxy resin -based sealer that has been successfully used for many years, in conjunction with gutta percha, for filling of root canals. AH plus exhibited a higher bond strength to dentin than ZOE , glass ionomer & calcium hydroxide based sealers[8].

MTA Plus is a calcium silicate based bioceramic cement, used as a root canal sealant. An advantage of MTA Plus is the particle size , which is 50% smaller than MTA & $< 1\mu m$[9]. MTA based sealers have been claimed to be biocompatible & to simulate biomineralization resulting in superior seal[10]. MTA sealers showed sealing ability similar to epoxy resin based sealers[11].

Sealer penetration into the dentinal tubules improves the sealability because of an increase of contact surface between filling material and dentin[12]. The bond strength of sealers to dentin is important for the maintenance of integrity of seal[13]. The present study was designed to compare and to evaluate the penetration depth and push-out bond strength of C points and gutta percha using Bio-ceramic (MTA plus) and AH Plus root canal sealer.

AIM & OBJECTIVES

AIM:

To compare & evaluate the penetration depth & push-out bond strength of C points & Gutta percha using Bioceramic (MTA Plus) & AH Plus sealer in the root canal treatment.

OBJECTIVES:

1. To compare & evaluate the penetration depth of C points & Gutta percha using Bioceramic (MTA Plus) & AH Plus sealer which was mixed with Rhodamine-B dye using Confocal laser scanning microscope.

2. To compare & evaluate the push-out bond strength of C points & Gutta percha using Bioceramic (MTA Plus) & AH Plus sealer in Universal Instron testing machine at a crosshead speed of 0.5 mm/min until debonding occurred.

REVIEW OF LITERATURE

M. Ungor et al [13] (2006) evaluated the bond strength of the resin based sealer Resilon- Epiphany root canal filling system. He compared this with bond strengths of different pairings of AH Plus, gutta-percha , Epiphany and Resilon. A total of 65 extracted human single rooted teeth were used. All teeth were instrumented using a set of ProTaper rotary instruments . Irrigation was performed with 15 mL of 1.25% NaOCl between each instruments and the smear layer was removed during and after instrumentation with 5 mL of 17% EDTA. The canal spaces were filled with different combinations of sealers and core using the lateral condensation technique as follows: group A, AH Plus + Resilon; group B , Epiphany + Resilon; group C, Epiphany + gutta-percha; group D, AH Plus + gutta-percha ; group 5 (control), gutta-percha only. Cylinders of root dentine 1.13 (0.06) – mm long were prepared from the coronal sections of the 65 teeth. The test specimens were subjected to the push-out test method. After adhesion testing, the remaining sections were examined under a stereomicroscope at x 25 magnification to determine the nature of bond failure. The Epiphany sealer and Resilon core combination was not superior to that of the AH Plus sealer and gutta-percha core combination.

A. Jainaen et al [1] (2007) assessed three resin sealer's push-out bond strength of the sealer- dentine interface with and without main cone. 30 extracted maxillary premolar teeth having two separate canals were selected and prepared using 0.04 taper Profile instruments upto size 35 – 45. Teeth were divided into 3 groups for filling using EndoREZ, Resilon sealers or AH Plus TM. In each tooth, one canal was filled with sealer alone & other with a matching single cone technique. A Mid-root dentine slice of 1 mm was prepared for the push-out test. After push-out test, failure modes were examined under microscopy and field emission- scanning electron microscopy. Resin sealers when present as a thin layer, push-out bond strength was lower. Sealers failed in the cohesive mode within the thin film, leaving a layer of sealer on the canal surface. Bulk sealer showed predominantly adhesive failure at the dentin – sealer interface.

K. Mamootil et al [12] (2007) evaluated the consistency & depth of penetration of three root canal sealers into dentinal tubules in extracted teeth and to measure the penetration of an epoxy resin-based sealer cement in vivo. Root canals of Fifty extracted human premolar teeth were prepared and obturated using three different sealer cements based on epoxy resin (AH26), zinc oxide eugenol (Pulp Canal Sealer EWT) and methacrylate resin (EndoREZ) . Five teeth filled without sealer were used as controls . Teeth were sectioned and prepared for observation using scanning electron microscopy. A further 12 teeth with a history of successful root filling and subsequent extraction were collected and sectioned. Consistency and appearance of the sealer within the tubules was observed & depth of sealer penetration into dentinal tubules was measured. The chemical and physical characteristics of the materials causes influence on the depth and consistency of dentinal tubule penetration of sealer cements . More consistent & deeper penetration was displayed by resin-based sealer. Penetration depths of epoxy resin-based sealer in- vivo were same with the experimental model. Penetration of sealer into dentinal tubules may be attributable by the decreased microleakage associated with smear layer.

Matthew A. Fisher et al [14] (2007) by means of push-out test design compared the bond strength of various obturation materials to root canal dentin. 25 single rooted extracted human teeth were selected. The teeth samples were sectioned & root canal instrumentation was completed by using Endogel-coated 0.06 Endosequence rotary files & irrigation was done with 5.25 % NaOCl & a final rinse with 17% EDTA. After instrumentation, the roots were randomly divided into 5 single-matched cone obturation groups (n = 5 roots/ group) , as follows: group1, EndoRez obturation system; group 2, Activ GP obturation system; group 3, gutta percha with AH plus; group 4, Resilon & Epiphany; & group 5, gutta percha with kerr EWT. To create 1- mm thick slices, obturated roots were cut perpendicularly to the long axis from the apical, middle & coronal thirds. The bond strength was measured using push-out testing machine. The higher bond strengths was found with gutta percha & AH plus sealer when compared with all other groups tested. Methacrylate resin-based sealer showed the lower bond strengths and root segment location has no significant difference.

Mehdi Rahimi et al[8] (2009) compared the microshear bond strength of three resin-based. Sectioning of 45 extracted maxillary premolars were done buccolingually. Then they were allocated for microshear bond testing with three resin sealers in thin & thick films. Failure modes were examined under scanning electron microscopy and light microscopy . The microshear bond strength was calculated in MPa. Overall, highest shear bond strength was found in epoxy resin-based sealer when compared with UDMA-based sealers. A thick sealer layer showed higher bond strength than thin film.

Neelakantan et al [15] (2011) assessed the usage of dentine conditioning impact on push out bond strength & sealing ability of an epoxy resin sealer. Ninety single-rooted teeth were selected & instrumented using a rotary Ni-Ti system. 40 canals were irrigated with 3% sodium hypochlorite during instrumentation, 50 canals with water. The sodium hypochlorite irrigated specimens received a final flush with a decalcifying agent (EDTA) and then 3% NaOCl and then the decalcifying agent (n = 10, each). A final flush was performed in the water-irrigated specimens with water (negative control), 3% NaOCl, 17% EDTA, 7% maleic acid (MA) or 2% chlorhexidine. Canals were all obturated with AH Plus. On day 3 and 30, Fluid transport was measured. Push out tests were performed in coronal, middle and apical root thirds. There is significant impact on sealing ability and bond strength of AH Plus when chemical treatment on dentine was done with commonly used irrigants. Moreover, a final flush with EDTA is advisable, while a final flush with NaOcl caused untoward effects on bond strength . AH plus appears to bond to the organic phase of dentine.

Eric Balguerie et al [16] **(2011)** evaluated the penetration depth, tubular adaptation and the adaptation of five different sealers in combination with softened gutta-percha cones to the root canal walls in the apical, middle, and coronal third of the root canal. 52 single -rooted teeth were selected and filled with five different sealers and softened gutta-percha. Then the samples were prepared for scanning electron microscopic evaluation. Sealer adaptation to the root canal, tubular walls & tubular penetration were assessed. The different physical and chemical properties of the sealers causes variations in tubular penetration and adaptation. Better tubular penetration & adaptation was shown by AH plus sealer.

Nikolaos Economides et al[17] (2011) evaluated the push-out bond strength of Smartseal system comparing it with gutta-percha-AH-26. 40 extracted single-rooted human teeth were selected. After instrumentation, the root canals were obturated as follows: Group 1, AH-26 sealer and gutta-percha using the cold lateral condensation technique; Group 2 , AH-26 sealer and a single F3 ProTaper gutta-percha cone; Group 3, Smartseal sealer and an F3 Smartpoint PT and Group 4, Smartseal sealer and a 0.06 taper Smartpoint calibrated to apical tip size 30. Slices from each root sample was cut in disk shape and subjected to push-out test. The result indicated that there is no difference in the bond strength between the Smartseal system and gutta-percha/AH-26.

S. M. B. S. Carneiro et al [18] (2012) assessed the push-out bond strength of several obturation materials to root dentine obturating by means of the thermomechanical compaction technique compared it with lateral compaction technique . 80 extracted canine teeth were selected, instrumented & filled with one of the following materials, using either thermomechanical compaction (n = 40) or lateral compaction (LC) (n = 40): Epiphany SE / GP (n = 10), Epiphany SE/Resilon (n = 10), Sealer 26/GP (n = 10) and AH Plus/gutta percha (GP) (n = 10). From each third of each root, three 2-mm-thick dentine slices were obtained. The samples were subjected to a push-out test to evaluate the bond strength of the materials to intraradicular dentine. Higher bond strength were found in lateral compaction technique with AH Plus and GP cones than thermomechanical compaction. The reason for highest bond strength of AH plus sealer may be due to its flowability & long polymerization time.

Emre Nagas et al [19] (2012) evaluated the push-out bond strength of root canal sealers which was effected by intraradicular moisture. 80 root canals were & assigned to four groups with respect to the moisture condition tested (1) moist: the canals were dried with low vacum by using a Luer adapter for 5 seconds follwed by 1 paper point for 1 second, (2) wet : the canals remained totally flooded, (3) ethanol (dry): excess distilled water was removed with paper points followed by dehydration with 95% ethanol & (4) paper points: the canals were blot dried with paper points with the last one appearing dry. The roots were further divided into four subgroups according to the sealer used (1) Epiphany, (2) MTA Fillapex, (3) iRoot SP & (4) AH plus. From each root sample, five 1-mm thick slices were obtained (n = 25) slices / group samples were subjected to push-out test. In all moisture conditions, the bond strength of iRoot SP to root dentin was higher than other sealers. The tested sealers showed the differential effects on experimental levels of moisture from dry to wet. Hence it suggests that it may be better to leave the canals slightly moist before filling procedures

Saurabh et al [7] (2012) with the aid of confocal microscopy evaluated the depth of penetration of four different resin sealers into the radicular dentinal tubules. 80 single rooted teeth were selected & instrumented and divided into 4 groups composed of 20 teeth each . The samples were obturated with RoekoSeal, EndoRez , RealSeal, and AH Plus resin sealers , respectively. Resilon was used as core material in all the groups. To determine the depth of penetration of the sealer into the dentinal tubules, teeth were sectioned at the coronal, middle, and apical thirds and viewed under confocal microscope. The maximum depth of penetration in the radicular dentinal tubules was found in RealSeal followed by AH plus, Roekoseal, Endorez. The coronal third showed the maximum penetration which was followed by the middle third and least in the apical third[7].

Chandra Vijay Singh et al[20] (2012) examined in vitro penetration depth of two resin based sealers (AH plus and Resino Seal) and Zinc Oxide Eugenol sealer into the dentinal tubules after removing smear layer by passive ultrasonic irrigation. Thirty freshly extracted maxillary central incisors were used. The teeth were decoronated, working length was established and prepared upto size 40 file. Each root was subjected to passive ultrasonic irrigation with 2.5% sodium hypochlorite. Three different sealers and gutta-percha were used for obturation. Roots were sectioned using hard tissue microtome. These sections were gold sputtered and examined under scanning electron microscope. This study showed that AH Plus sealer had maximum penetration depth into dentinal tubules as compared with Resino

Seal sealer and Zinc Oxide Eugenol. Structure and coherence of the sealer matrix into the dentinal tubules might be crucial factor determining the penetration depth of the smear layer free root canals[22]. Root canal filling materials should have low surface activity or an adequate surface active reagent to penetrate dentinal tubules. The fact that sealer penetration into dentinal tubules increases the interface between the filling material and dentin might influence the sealing ability of obturation and also reinforces the tooth.

Vineeta Nikhil et al [21](2013) by means of three different placement techniques compared the depth and percentage of sealer penetration using confocal laser scanning microscopy as the evaluative tool. 30 single-rooted human maxillary teeth stored in normal saline solution containing 0.1% sodium azide were selected & the coronal portions were cut and the root canal length standardized at 10 mm. Root canals were prepared to a size of F3. AH plus sealer mixed with Rhodamine B was applied with Endoactivator group A, lentulospiral group B and Ultlrasonic file group C. Obturation done with gutta-percha. At the 3 and 6 mm levels of root, horizontal sections were done from the apical foramen and were examined on a confocal microscope. All analysed placement techniques failed to show consistent adaptation of sealer to the total circumference of root canal . The penetration depth of sealer was influenced by the placement technique. Ultrasonic method showed the better result than other compared methods.

Sanjana Patil et al [22] (2013) evaluated the push-out bond strengths of three filling materials; Resilon/Epiphany self-etch (SE), Gutta-percha/AH Plus and EndoREZ obturation system. 60 extracted single-rooted, single-canal anterior teeth were selected, decoronated & instrumented. The sampes were assigned to groups (n=20); Group A gutta percha- AH plus , Group B Resilon - Epiphany SE and Group III: EndoREZ sealer / EndoREZ points. After obturation, each root was sectioned into slices of 2 mm thickness & subjected to push-out assessment using universal testing machine. No significant difference was found in the root segment. Gutta-percha/AH Plus root fillings showed highest bond strength. The teeth with simple anatomic features when obturated with /Epihany SE and EndoREZ , adhesiveness quality to root dentin was compromised because of C factor, with very limited unbounded surface area to provide relief from the polymerization shrinkage stress.

Gisselle Moraima Chávez-andrade et al[23] (2013) investigated MTA-based cement by measuring its flowability, setting time, pH, calcium release and bond strength s utilized and for the setting time test, the ASTM C266-03 specification was utilized. For pH and calcium release measurements, 10 samples were prepared for each group and analyzed for several different periods. For the push-out test, dentin disks were distributed into 3 groups, according to the cement utilized. Into 3 subgroups, according to the root third. After obturation , the specimens were subjected to push-out testing. Several similar properties were found between MTA Fillapex and Sealapex and both were found to be different than AH Plus. MTA fillapex showed is lower bond strength than AH plus.

J. Camilleri et al [24] (2013) exposed mineral trioxide aggregate (MTA) Plus to different environmental conditions to assess its hydration reaction. The surface morphology , characterization of un-hydrated MTA Plus & specific surface area were investigated. ProRoot MTA was used for the comparison. The reaction rate was determined by calorimetry. The hydrated cement was assessed for the setting time & the set material was characterized by X-ray diffraction analysis, X-ray energy-dispersive analysis and scanning electron microscopy. By means of atomic ratio plots, relationship of the hydration products were established. Three different environmental conditions used in the study was namely immersed in either water or Hank's balanced salt solution (HBSS) or dry. The novel MTA Plus had a similar chemical composition but was finer than ProRoot MTA. The physiological solution interaction resulted in inhibition of hydration. MTA plus hydrate in contact with the solution, leaching & microcracking of calcium hydroxide. MTA Plus exhibited partial decalcification of calcium silicate in direct contact with fluids.

Prasanna Neelakantan et al[25] (2013) using rotary retreatment system, evaluated the removal of two MTA-based sealers (MTA Fillapex & MTA Plus), considering an epoxy resin sealer (AH plus sealer) as the standard for comparison. Forty - five single rooted teeth were instrumented & obturated with gutta percha using (n = 15); group I, MTA Fillapex; group II, MTA plus and group III, AH plus . Scanning of teeth were done using cone beam computed tomography scanner. Teeth were retreated using rotary retreatment system after 2 months & again cone beam computed tomography were done to assess remaining filling material (in percentage) & dentin removal (in mm^3). Group comparisons were done by one-way analysis of variance & student - Newman- keuls post hoc test .The time taken to reach the working length were calculated in minutes. MTA Fillapex was less remaining than MTA plus. Rotary retreatment files cannot remove any of the materials completely.

Anthony Didato et al [5] (2013) compared the lateral expansion of two sizes & two batches of water- expandable obturation points -C points in a time based manner. A similar - sized gutta-percha point at various distance from the point apex: 5, 10 & 15 mm used as control. A single lot of size 40 (0.06 taper) gutta percha were tested & two batches of sizes 25 & 40 (0.06 taper) C points (N=5). Digital images under 50x magnification were obtained for the each points location after fixing it to the bottom of petridish which also captured a caliberated linear scale reticule. After, 10 ml of water was added to the samples after imaging each dry cone location & images were obtained at various time : 20 & 40 mins, 1,2, 3,4, 5, 6, 7,8 & 24 h.dishes were stored at 37ºC between each measurements. Using imaging software, side-to-side dimension of each point was determined. A new hydrophilic endodontic obturation point expands laterally when exposed to water & significantly increases in dimension within 20 min. But a conventional gutta-percha point does not. This is because C points fills the anatomical gaps by utilizing the principle of hygroscopic expansion & potentially provide a better seal.

Suprit Sudhir Pawar et al[26](2014) evaluated the microleakage of three sealers namely ; AH Plus Endosequence bioceramic (BC) sealer, and Epiphany. Seventy-five extracted human single rooted permanent teeth were selected for the study, which were decoronated and the root canals were instrumented. The samples were randomly divided into three groups (n = 25) and obturated by means of continuous wave condensation technique. Group 1: using Endosequence BC, Group 2: using AH Plus sealer, Group 3: using Resilon Epiphany system. Microleakage was evaluated by means of dye penetration method. Then the samples were split longitudinally and horizontally. Markings were made at 2, 4 and 6 mm from the apex. Under stereomicroscope (30X magnification), dye penetration evaluation was done. Microleakage cannot be totally eliminated from the fate of a root canal treated teeth. This is because of presence of lateral canals, accessory canals and other anatomical variation which play an important role in this, with periapical pressure being the main factor. Newer root canal sealers seal the root canal better but cannot totally eliminate leakage.

Shashank Arora et al [27](2014) evaluated homogeneity of a novel polyamide polymer based obturating system and Gutta-percha and sealer in filling simulated lateral canals when used for obturating the root canals. A total of sixty freshly extracted human single rooted teeth with fully formed apices were selected for this study. Teeth were decoronated, working length was standardized to15 mm & root canal preparation was carried out with rotary Protaper file system in all groups. The samples were then randomly divided into three groups 1, 2, and 3 (n = 20). 10 specimens from each group were decalcified and simulated lateral canals were made at 2, 4, and 6 mm from the root apex. Remaining 10 samples of each group were maintained calcified. Group 1 was obturated with SmartSeal system (Prosmart-DRFP Ltd., Stamford, UK). Group 2 was obturated with sectional backfill method. Group 3 was obturated with cold lateral compaction method (control). Calcified samples were subjected to cone beam computed tomography image analysis sectioned axially. Using digital radiography and photography, decalcified samples from the respective groups were analyzed. The measurements of the linear extension and area of lateral canal filling was done using UTHSCSA (UTHSCSA Image Tool for Windows version 3.0, San Antonio, TX, USA) software. Gutta-percha system proved to have lower efficiency when compared with Polyamide polymer obturation, when used for obturation with regards to adaptation of the sealer and penetration into the simulated lateral canals. Polyamide polymer has shown a greater area and linear expansion, which is because of the hygroscopic expansion of the poyamide polymer system[27].

Vibha Hegde et al [4] (2015) using a bacterial leakage model evaluated the apical sealing ability of Novel Smart seal system, Resilon & gutta percha. 70 extracted single rooted human teeth were selected, decoronated and instrumented using protaper rotary. Then the samples were divided into three groups (20 each) and two control groups (5 positive and 5 negative) Group 1 with filled with Smart-seal system, Group 2 with Resilon, Group 3 with Gutta percha. Sealing ability of the sealers were evaluated using Enterococcus feacalis- split chamber bacterial leakage model. Resilon & Smart seal system showed better performance than Gutta percha. Hydrophilic filling materials showed better resistance to bacterial leakage than hydrophobic materials.

Prasanna Neelakantan et al [28](2015) using Fourier transform infrared spectroscopy (FTIRS) & measurement of dislocation resistance, analyzed the influence of irrigation on the chemical interaction between dentin & root canal sealer. One-hundred twenty single rooted teeth were selected & instrumented & irrigated using 3% sodium hypochlorite. Samples were divided into 4 groups (n = 30) based on irrigation protocols: group A, 3% sodium hypochlorite, 17% EDTA, water; group B, 17% EDTA, 3% sodium hypochlorite, water; group C, 3% sodium hypochlorite, QMix, water; group D, 3% sodium hypochlorite, water. Based on root canal sealer used, each group was subdivided into three subgroups (n = 10): I, epoxy resin (AH plus); II, silocone (RoekSeal); III, calcium hydroxide (sealapex). By means of push out bond strength test, the dislocation resistance was assessed. Data were analysed by three-way analysis of variance & Holm sidak tests (p = .05). AH plus sealer (epoxy resin) chemically bonds to dentin, hence this interaction was influenced by irrigation protocols. Irrigation protocols differentially affect the bond strength.

H. M. Abada et al [29] (2015) compared push-out strength of 4 obturation system namely; RealSeal, gutta percha / AH plus, EndoREZ & Gutta flow system to root canal dentin. Freshly extracted eighty human mandibular premolars were selected & prepared & assigned to experimental groups (n=20), designated as Group A: Gutta percha / AH plus, Group B: GuttaFlow system, Group C: RealSeal points / RealSeal self-etch & Group D: EndoREZ obturation system. After obturation, root slices of 2 mm thickness of each tooth was prepared for push-out assessment using universal testing machine. Even when teeth with simple anatomic features were obturated under well-monitored laboratory conditions, the adhesiveness quality to root dentin promoted by newer methacrylate resin-based obturation system like RealSeal & EndoREZ systems is compromised.

Rogério Vieira Silva et al[30] (2015) applied according to the vertical condensation technique using thermoplastic gutta-percha, evaluated the filling effectiveness and dentinal penetration of the sealers AH Plus, Pulp Canal Sealer EWT, Sealapex and MTA Fillapex. 40 single-rooted teeth were selected & chemical-mechanical preparation and root-canal filling was done. The sections of the root (2, 4 and 6 mm from the apex) were obtained and analyzed by confocal laser scanning microscopy & stereo microscopy. Except the MTA Fillapex, which showed failures at 4 and 6 mm from the root apex, all 4 sealers were found to be similar regarding adaptation of the filling material to the root canal walls. With regard to the ability to penetrate into the dentinal tubules, except for the Pulp Canal Sealer EWT, all the sealers were found to be equivalent. Pulp Canal Sealer EWT, as it had poorer results at 4 and 6 mm compared to MTA Fillapex and AH Plus, respectively.

Afaf AL-HADDAD et al[31] (2015) evaluated interfacial adaptation of bioceramic sealers& the sealer thickness to root dentin against AH Plus® sealer. 60 extracted single-root premolars were selected & prepared and equally divided into 4 groups & sealers were labeled with 0.1% Rhodamine B fluorescent dye. Along the transverse plane at 1 mm (apical), 3 mm (middle), and 6 mm (coronal) levels, roots were dissected. Whole canal-to-sealer area ratio was evaluated. Using a confocal laser microscope, percentage of gap-containing region to canal circumference was calculated. Sealer thickness was significantly higher at middle and apical levels than at coronal level. MTA Fillapex and AH Plus had the significantly lowest thickness compared with EndoSequence BC. Bioceramicsealers showed more gaps compared with AH Plus, with no significant differences among them. The coronal level had significantly less interfacial gaps compared with apical and middle levels.

Mohammed Abdul Khader et al [32] (2016) using Scanning Electron Microscopy, compared the penetration depth of three root canal sealers AH Plus, Tubli-Seal and Apexit Plus with different compositions. A total of thirty single-rooted mandibular premolars were selected & decoronated and the canal preparation done by step back technique was used for this study. 17% of EDTA was used as final flush. Prepared samples were divided into 3 groups of ten teeth each, and different sealers were used for each group -resin-based sealer - AH Plus®, calcium hydroxide-based - Apexit® Plus, and zinc oxide eugenol-based - Tubli-Seal™. Teeth were split longitudinally after obturation and viewed under SEM. ™). No statistically significant difference between apexit plus and AH plus. There was no statistically significant difference among the means of measured depth of penetration of Apexit®and AH Plus® sealer. However, Tubli-Seal™ values projected statistically significant differences. Calcium hydroxide-based sealer (Apexit® Plus) and resin-based sealer (AH Plus®) showed high depth of penetration as compared to the Zinc oxide eugenol-based sealer (Tubli-Seal)

Derya Deniz Sungur et al [33] (2016) compared the push-out bond strength and dentinal tubule penetration of coated core materials and conventional gutta-percha using root canal sealers. A total of seventy two single-rooted human mandibular incisors were selected and instrumented with NiTi rotary files with irrigation of 2.5% sodium hypochlorite. The smear layer was removed with 17% EDTA. Specimens were assigned into 4 groups according to the obturation system: Group A, EndoRez (Ultradent Product Inc.); Group B, Activ GP

(Brasseler); Group C, SmartSeal (DFRP Ltd. Villa Farm); Group C, AH 26 (Dentsply de Trey)/gutta-percha (GP). Two horizontal slices were obtained from each specimen (*n* = 20) for push-out bond strength measurement. Remaining thirty two roots assigned to four groups as above were obturated with 0.1% Rhodamine B labelled sealers, to compare dentinal tubule penetration. For penetration depth measurement, one horizontal slice was obtained from the middle third of each specimen (*n* = 8) and scanned under confocal laser scanning electron microscope. Tubule penetration depth, area and percentage were measured. Kruskall-Wallis test was used for statistical analysis. The bond strength and sealer penetration of resin-based sealer used with conventional GP was superior to resin and glass ionomer-based sealers used with coated core. The use of conventional GP with sealer seems to be sufficient in terms of push-out bond strength. Dentinal tubule penetration has limited effect on bond strength.

G. Vijaya Madhuri et al [34](2016) through push-out test design, compared the bond strength of 4 different endodontic sealers to root dentin. 40 single-rooted teeth with completely formed apices were selected & were decoronated & the working length was determined. Instrumentation and irrigation were performed & the samples were divided into 4 groups based upon the sealer used. Group A: Bioceramic sealer (Endosequence), Group B: Mineral trioxide aggregate (MTA) based sealer (MTA Fill apex), Group C: Epoxy resin based sealer (MM-Seal), and Group D: Dual cure resin-based sealer (Hybrid Root Seal). Using 6% gutta-percha, all the teeth were obturated. After obturation, each tooth with root slices of 2 mm thickness was prepared for push-out test using universal testing machine. Lowest bond strength was observed in MTA-based sealer.The push-out bond strength of Bioceramic sealer was highest followed by resin-based sealer and hybrid root seal.

Pankaj Mishra et al [35](2017) evaluated the push-out bond strength of two endodontic obturation materials to intraradicular dentin. 40 extracted single rooted permanent teeth were selected for the study & teeth were instrumented. The specimens were divided into 2 groups each containing 20 specimens obturated with different obturation material; GroupA Epiphany /Resilon and Group B Gutta Percha/AH Plus. Element Obturation unit (Sybron Endo) was the obturation systems used in this study. From the coronal 1/3rd, middle 1/3rd and apical 1/3rd, each tooth root was horizontally sectioned in approximately 2-mm thick slices. Using Universal Testing Machine, the push-out bond strength of each specimen was calculated. The interfacial bond strength achieved with AH Plus/Gutta Percha to intraradicular dentine was superior to that of Resilon/Epiphany self-etch (SE). In both groups , apical 3rd showed higher pushout bond strength, followed by middle 3rd and the least at the coronal 3rd .

Vibha Hegde et al [36] (2017) using the confocal laser scanning microscopy (CLSM), evaluated the effects of 3 root canal sealer activation techniques on percentage and depth of penetration of AH Plus sealers &SmartPaste Bio.60 teeth were instrumented till rotary F3 ProTaper size. The samples were divided into two equal groups on the basis of type of sealer used: SmartPaste Bio sealer (Endotechnologies, LLC, Shrewsbury, MA, USA) & AH Plus (Dentsply–DeTrey, Konstanz, Germany) . For visibility under CLSM, sealers were mixed with Rhodamine B. On the basis of sealer activation technique, each group was further divided into three equal subgroups: (i) manual dynamic, (ii) ultrasonic, and (iii) Sonic. Obturation of the samples were done using gutta‑percha by cold lateral condensation. Horizontal sections at 3 mm from the apex were obtained, and the percentage and depth of penetration of sealers into dentinal tubules were measured using CLSM. The type of sealer used and the sealer activation technique causes influence on percentage and depth of sealer penetration. The better results was seen in SmartPaste Bio sealer and ultrasonic method of activation. This is because of its properties such as slight expansion on setting and low contact angle, remarkable flowability due to its nonoparticle size and hydrophilicity.

Luciana Martins et al [37] (2017) evaluated with and without the butterfly effect, penetration depth and adaptation quality of root canal sealers and ProRoot MTA into bucco-lingual and mesio-distal aspects of roots. Some roots due to density of dentinal tubules shows the butterfly effect. 120 teeth were selected, decoronated , prepared and assigned to obturation groups: gutta-percha with a sealer- AH Plus, EndoREZ, Kerr Pulp Canal Sealer, MTA Fillapex or ProRoot MTA alone (each containing 10 butterfly and 10 non-butterfly roots). Confocal laser scanning and scanning electron microscopy were used to assess penetration and adaptation. Teeth with the butterfly effect had greater mean penetration bucco-lingually than mesio-distally. Butterfly effect improves treatment outcome.

MATERIALS & METHODS

Armamentarium used in the study

- Extracted teeth
- Stainless steel K file sizes 8, 10, 15 (Dentsply Maillefer)
- Xsmart plus (Dentsply Maillefer)
- Protaper rotary files (Dentsply)
- 5.25% Sodium hypochlorite
- Normal saline
- 17% EDTA
- Gutta-percha cones (Dentsply Maillefer) – single cone technique
- C Points
- Diamond disc & mandrel
- Disposable syringe
- AH Plus sealer
- MTA plus sealer
- Rhodamine B dye
- GP cutter

MATERIALS & METHODS

80 single rooted teeth (mandibular premolar) extracted due to orthodontic and periodontic reasons, collected from Department of Oral Maxillofacial Surgery in KSR Institute of Dental Science & Research.

INCLUSION CRITERIA:

- Mandibular first premolars
- Complete root formation without signs of internal or external resorption, no fracture or crack in the root
- No coronal restoration or decay below the cement enamel junction (CEJ)
- Straight cone root without curvature in the apical third
- No calcification in the root canal.

EXCLUSION CRITERIA

- Multiradicular teeth.
- Teeth with multiple canals.
- Teeth with any anomalies

PREPARTION OF THE TEETH

The extracted teeth were cleaned by removing all attached hard & soft tissues & immersing in 5.25% sodium hypochlorite for 24 hrs. Then the teeth were stored in the container with lid containing sterile saline at room temperature until further processing. The crown of the teeth were decoronated at the cemento-enamel junction with a diamond disk under water coolant & a standardized root length of 15 mm was obtained.

For Biomechanical preparation, X smart plus (DENTSPLY Maillefer) & Protaper instruments (DENTSPLY Maillefer) with crown down technique were used. The working length was determined by subtracting 1 mm from the length of an inserted #10 K-file with its tip visualized at the apical foramen. Eighty teeth were instrumented up to a master apical file size of F3 with ProTaper rotary instruments (Dentsply Maillefer) by using a 16:1 reduction hand piece with a torque- and speed-controlled electric motor (X Smart; Dentsply Maillefer). The speed and torque values were set as recommended by the manufacturer. The canals were irrigated by using 2 mL of 5.25% sodium hypochlorite (NaOCl) solution between each file size (Sx, S1, S2, F1, F2, F3). After instrumentation, the smear layer was removed by flushing the root canals with 17% ethylenediaminetetraacetic acid (EDTA) solution. The canals were finally rinsed with 10 mL distilled water and dried with ProTaper paper points.

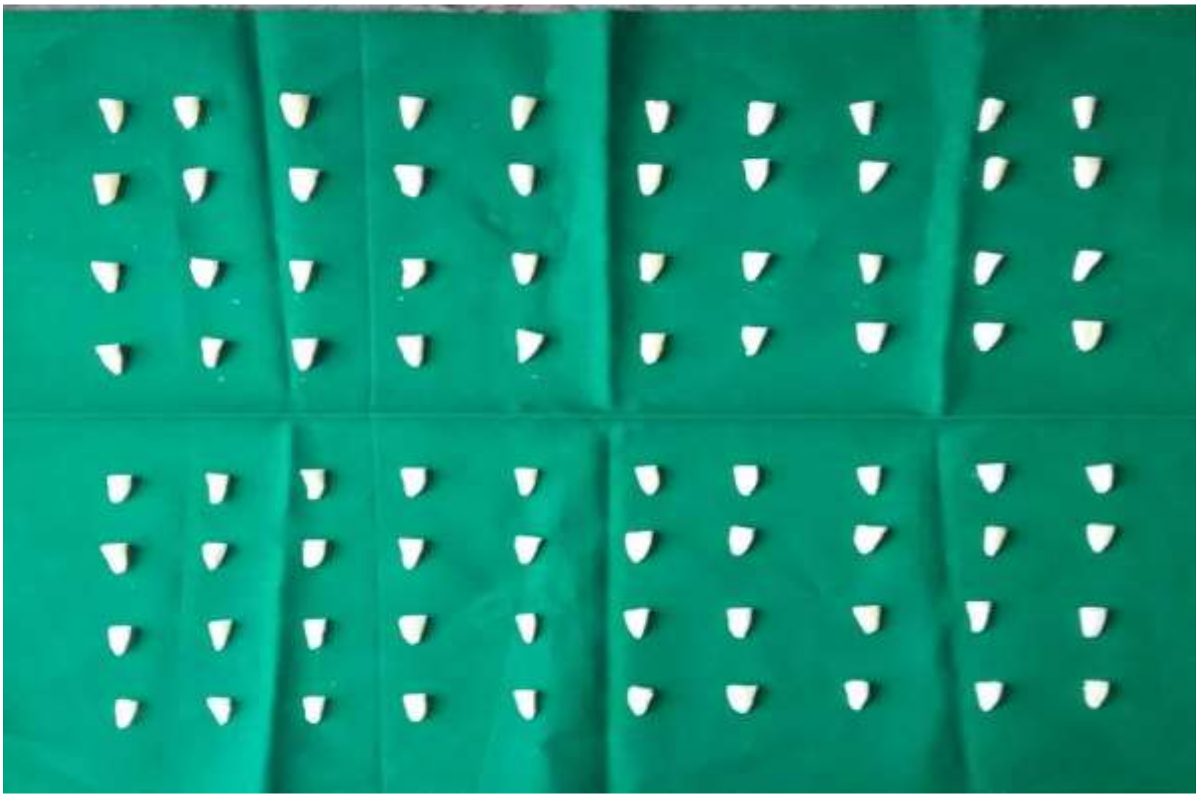


Figure 1: Sectioned teeth samples

Figure 2: C points

Figure 3: Armamentarium

Figure 4: MTA Plus sealer

Figure 5: Confocal Laser Scanning Microscope

Figure 6: Universal Testing Machine

Figure 7: push – out Bond Strength Analysis

GROUPING

The selected teeth were randomly divided into four groups (n = 20)

Group 1 - Obturation done using C points with MTA plus sealer

Group 2 - Obturation done using C points with AH Plus sealer

Group 3 – obturation done using F3 size GP with MTA plus sealer

Group 4 – obturation done using F3 size GP with AH plus sealer

OBTURATION

In group 1: Samples filled with single C point cone & MTA Plus (bioceramic). The cone (F3) that allowed insertion to the WL was selected and its position was confirmed using a radiograph. The powder was mixed with a gel supplied by the manufacturer to a syrupy, stringy consistency & mixed with Rhodamine B dye. The canal wall is then coated with dye mixed sealer using master cone. The selected C-Point cones were placed in the canals and the excess of the cone was sheared off at the CEJ level using a round carbide bur in a slow speed handpiece without water. No additional cones were used. The access cavities were sealed with composite resin (Tetric). The teeth were maintained at 100% humidity for 7 days at 37°C to allow the sealer to fully set.

In group 2: Samples filled with single C point cone & AH sealer. The largest cone (F3) that allowed insertion to the WL was selected and its position was confirmed using a radiograph. The catalyst & base paste of AH plus sealer was dispensed into the mixing pad, which is then mixed with Rhodamine B dye. The canal wall was then coated with dye mixed AH Plus sealer using a master cone. The selected C-Point cones were placed in the canals, and the excess of the cone was sheared off at the CEJ level using a round carbide bur in a slow speed handpiece without water. No additional cones were used. The access cavities were sealed with composite resin (Tetric). The teeth were maintained at 100% humidity for 7 days at 37°C to allow the sealer to fully set.

In group 3, Samples filled with single GP point cone & MTA Plus (bioceramic). An F3 master gutta-percha cone (Dentsply Maillefer) with good tug-back that allowed insertion to the WL was selected and its position was confirmed using a radiograph. The powder was mixed with a gel supplied by the manufacturer to a syrupy, stringy consistency & mixed with Rhodamine B dye. The canal wall is then coated with dye mixed sealer using master cone. The selected GP cones were placed in the canals and the excess of the cone was sheared off at the CEJ level using GP cutter & condensed with heated instrument. No additional cones were used. The access cavities were sealed with composite resin (Tetric). The teeth were maintained at 100% humidity for 7 days at 37°C to allow the sealer to fully set.

In group 4: Samples filled with single GP point cone & AH Plus sealer. An F3 master gutta-percha cone (Dentsply Maillefer) with good tug-back that allowed insertion to the WL was selected and its position was confirmed using a radiograph. The catalyst & base paste of AH plus sealer was dispensed into the mixing pad, which is then mixed with Rhodamine B dye. The canal wall was then coated with dye mixed AH Plus sealer using a master cone. The selected GP cones were placed in the canals and the excess of the cone was sheared off at the CEJ level using GP cutter & condensed with heated instrument. No additional cones were used. The access cavities were sealed with composite resin (Tetric).

The teeth were maintained at 100% humidity for 7 days at 37°C to allow the sealer to fully set.

SAMPLE SECTIONING

Each sample was sectioned horizontally into 2 mm thick slices at each of the three thirds – coronal (3-5 mm), middle (7-9 mm), and apical (11-13 mm) of the root using a diamond disk with continuous water flow. A digital caliper was used to measure the thickness of each sample. A permanent marker was used to denote the coronal surfaces of each sample.

DEPTH OF PENETRATION TEST USING CONFOCAL MICROSCOPE

All samples were examined with confocal laser scanning microscope. A helium neon laser was used as the light source and the excitation light source had a wavelength of 543 nm. The fluorescent light was collected beyond 560 nm. The confocal laser scanning microscopic (CLSM) images were recorded in the fluorescent mode. Images recorded at X10 had a numeric aperture of 0.4. The size of the X10 images recorded was 1550 X 1550 μm^2 with a resolution of 512 X 512 pixels. Each X10 sample was evaluated for a consistent fluorescent ring around the canal wall, indicating the sealer-dye distribution. The area of deepest penetration was recorded and viewed at X20. The depth of penetration of the sealer into the dentinal tubules was depicted by the fluorescence, which was traced from the resin-dentin junction until the maximum depth. The measurements were recorded by using the digital measuring ruler, a feature present in the CLSM image recorder software. The canal wall served as the starting point and sealer penetration was measured to the outer limit of the visible field in the microscope. The data were averaged to obtain a single value for each section. A single operator analyzed all the specimens to rule out any discrepancy. The values of penetration depth were analyzed by one-way analysis of variance (anova) and the post hoc Tukey's test, with significance set at $P < 0.05$.

PUSHOUT BOND STRENGTH TEST

The cylindrical stainless steel plunger tip of 0.5 mm in diameter was selected and positioned to cover as much as possible of the root filling, yet avoiding any contact with the canal walls. The load was always applied in an apical-coronal direction to avoid any constriction interference that may have been caused by the root canal taper during push-out testing.

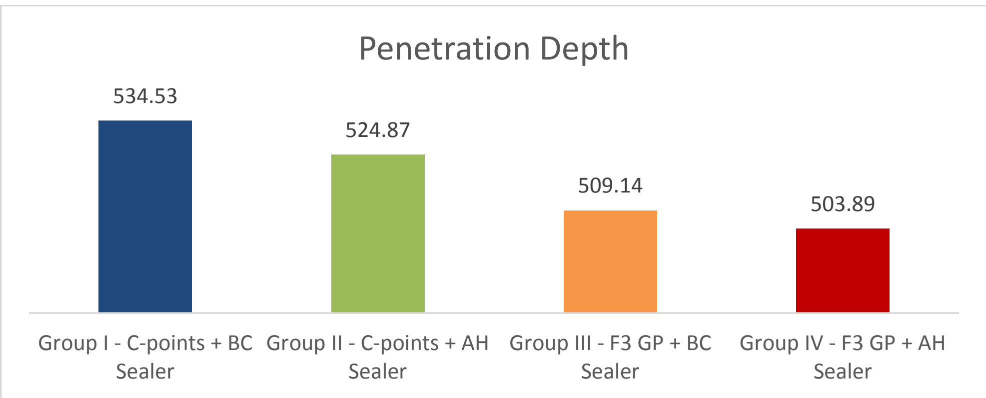
Loading was performed with a Universal Instron testing machine at a crosshead speed of 0.5 mm/min until debonding occurred. The force applied at debonding was recorded in Newtons. The load at failure recorded in Newtons. The bond strength was then expressed in megapascals (MPa). The values of bond strength were analyzed by one-way analysis of variance (anova) and the post hoc Tukey's test, with significance set at $P < 0.05$.

RESULTS

PENETRATION DEPTH

Groups	N	Mean	S.D.	S.E.	95% C.I.	Min.	Max	F-value	P-value*
Group I (C-points + BC Sealer)	60	534.53	50.44	6.51	521.50-547.56	427.38	657.88	2.458	0.064
Group II(C-points + AH Sealer)	60	524.87	66.58	8.59	507.67-542.07	340.93	652.58		
Group III (F3 GP + BC Sealer)	60	509.14	69.96	9.03	491.06-527.21	300.13	669.25		
Group IV (F3 GP + AH Sealer)	60	503.89	87.13	11.24	481.38-526.40	152.95	666.70		

Table 1: Comparison of mean penetration depth among the four groups



Graph 1: Comparison of mean penetration depth among the four groups

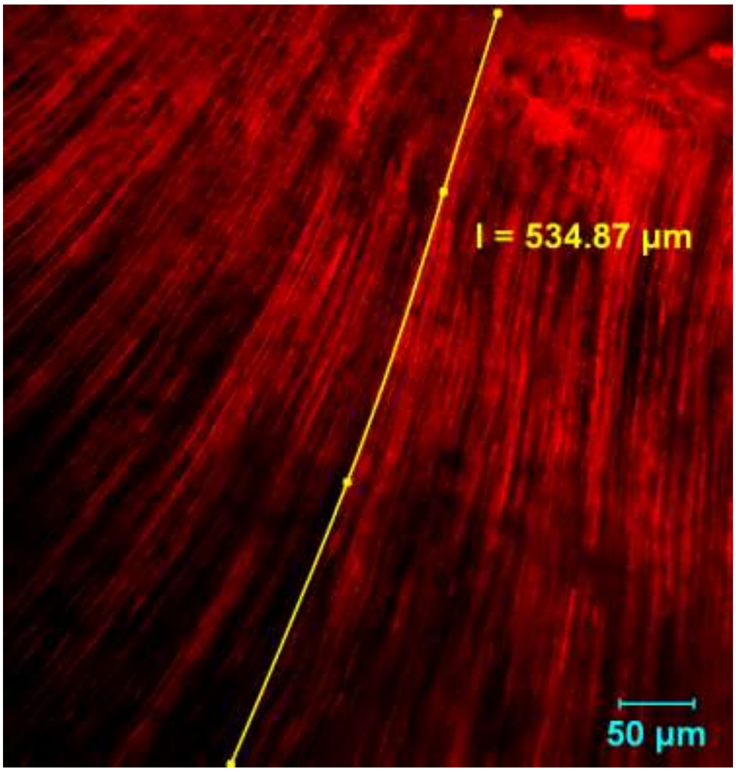


Figure 8: Mean value of Group I C points + BC sealer

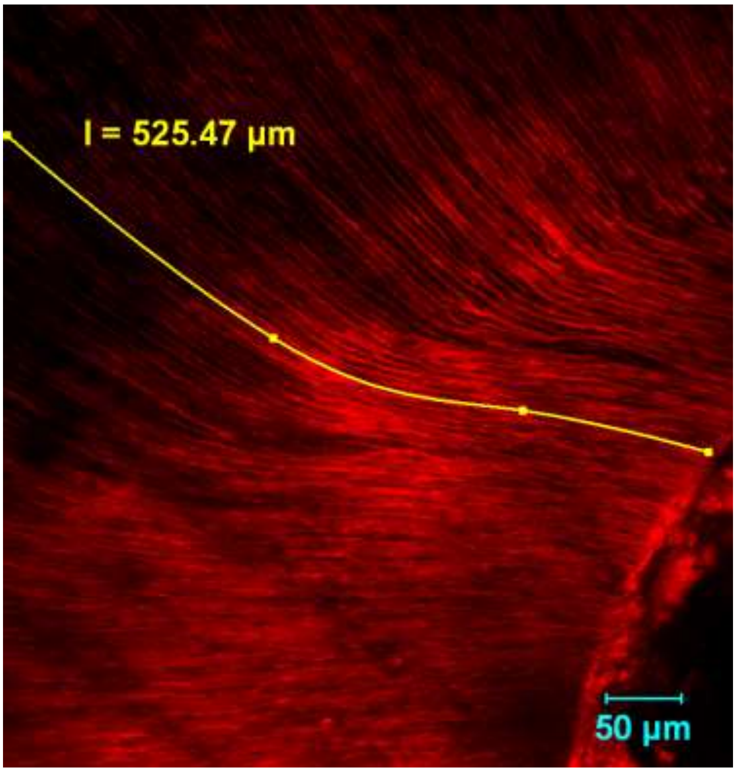


Figure 9: Mean value of GroupII - C points + AH plus sealer

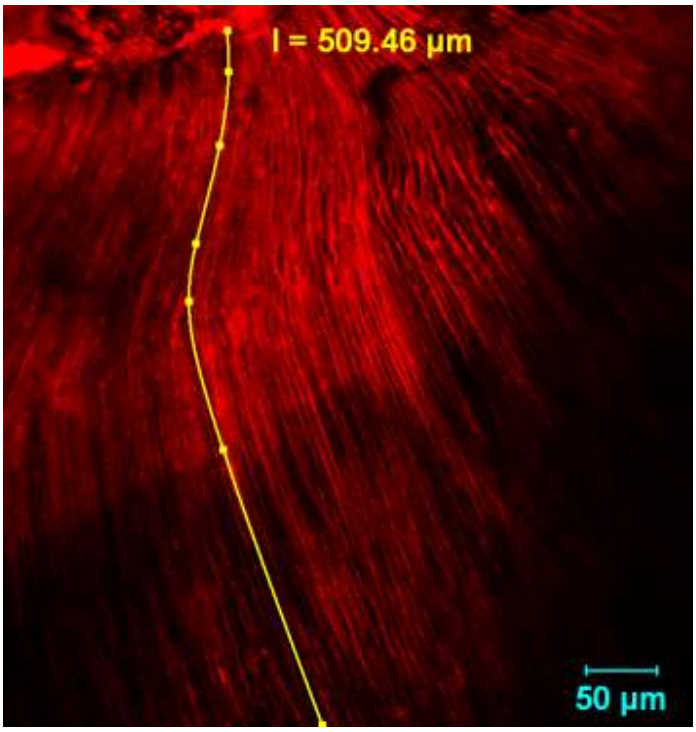


Figure 10: Mean value of Group III – F3 GP + BC sealer

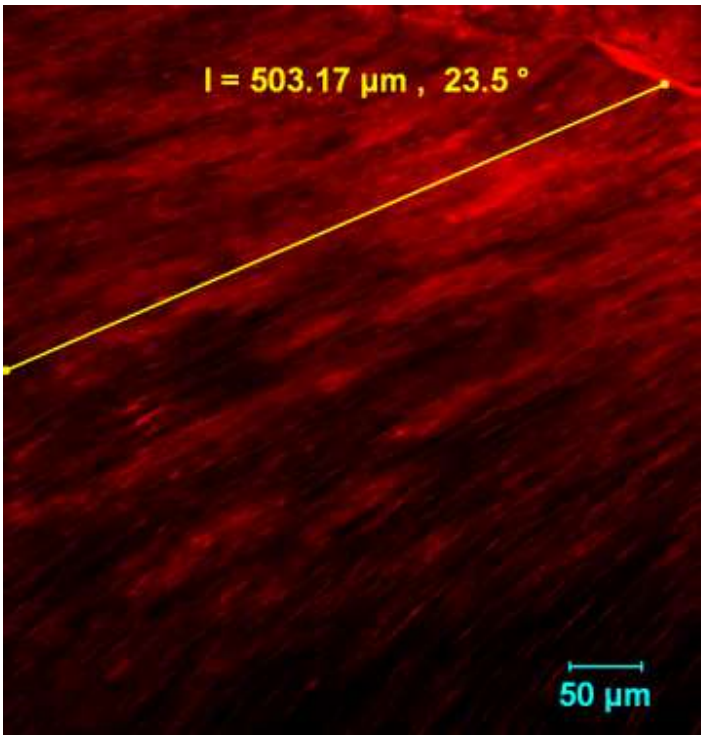
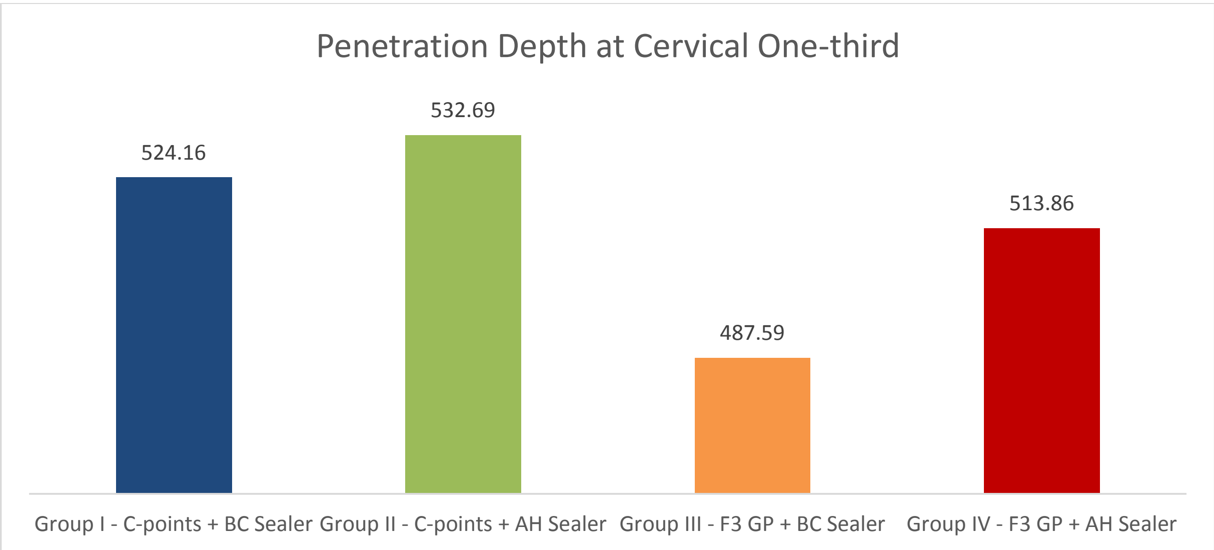


Figure 11: Mean value of

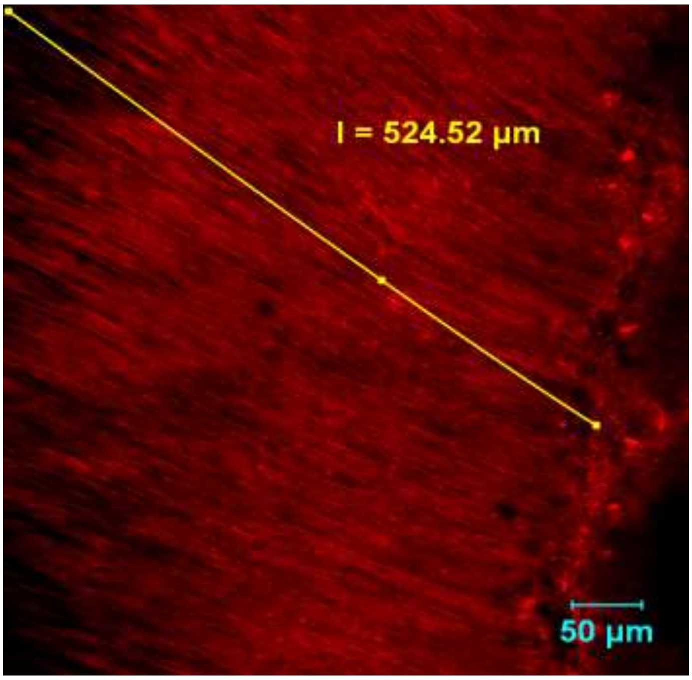
Group IV – F3 GP+ AH plus sealer

Groups	N	Mean	S.D.	S.E.	95% C.I.	Min.	Max	F-value	P-value*
Group I (C-points + BC Sealer)	20	524.16	54.48	12.18	498.66-549.66	459.36	631.59	1.852	0.145
Group II (C-points + AH Sealer)	20	532.69	55.18	12.33	506.87-558.52	427.38	622.32		
Group III (F3 GP + BC Sealer)	20	487.59	73.50	16.43	453.19-521.99	300.13	605.57		
Group IV (GP + AH Sealer)	20	513.86	71.57	16.00	480.36-547.36	416.61	666.70		

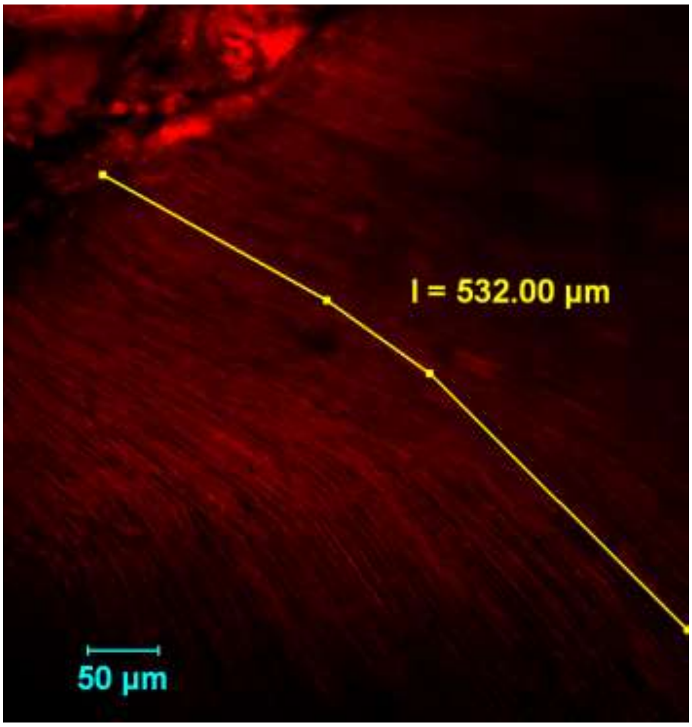
Table 2: Comparison of mean penetration depth among the four groups at cervical one-third



Graph 2: Comparison of mean penetration depth among the four groups at cervical one-third

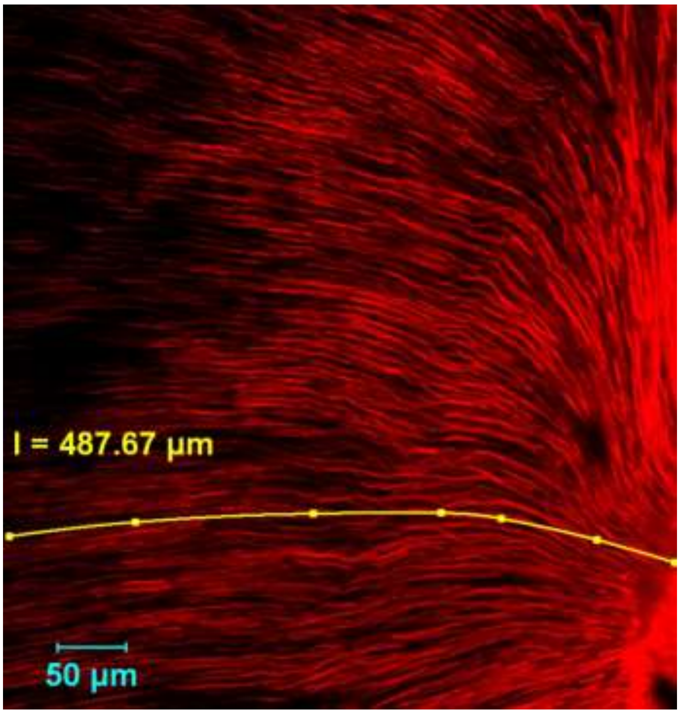


Group I- C Points + BC sealer

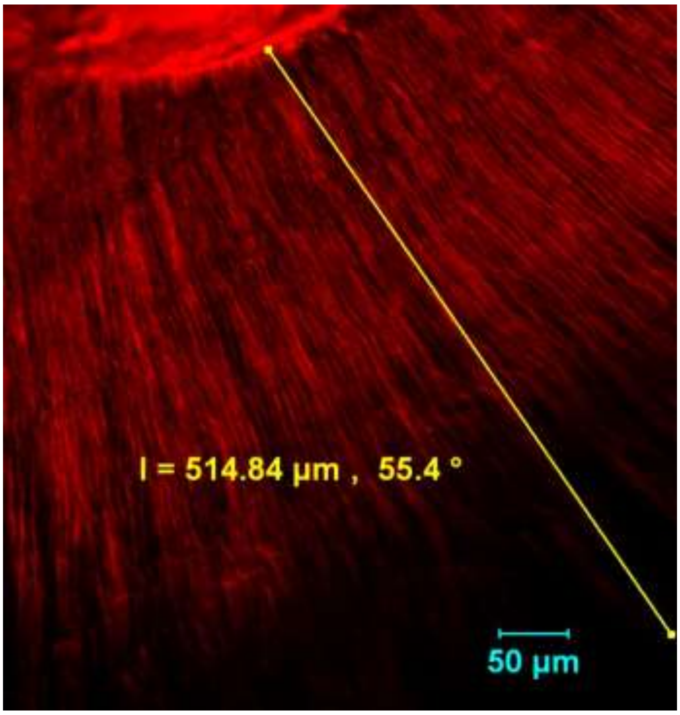


Group II- C points + AH plus sealer

Penetration depth at cervical one - third



Group III- F3 GP + BC sealer

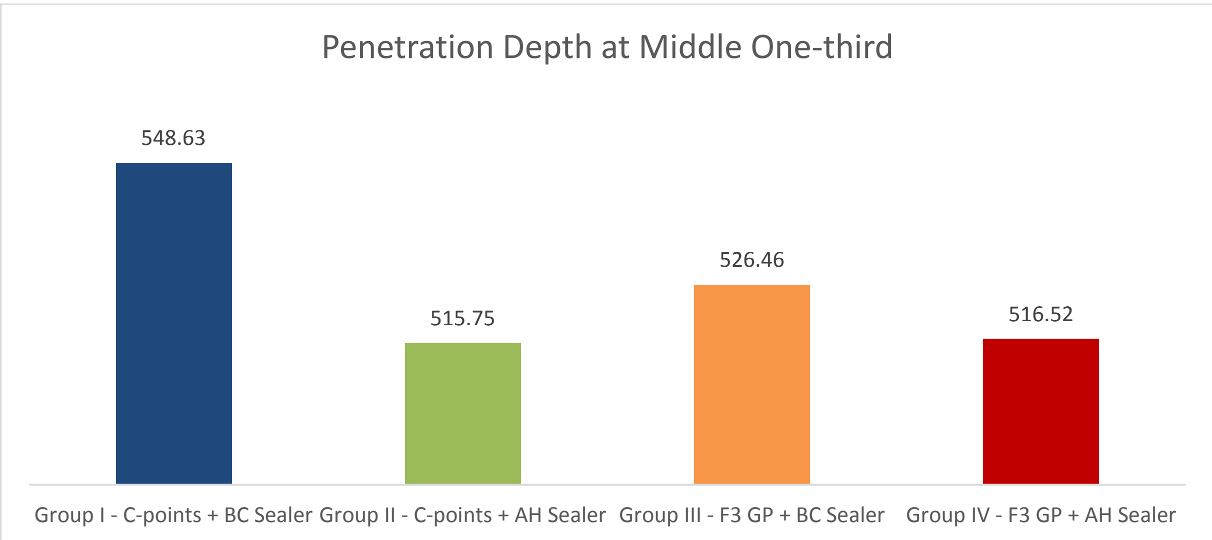


Group IV- F3 GP + AH plus sealer

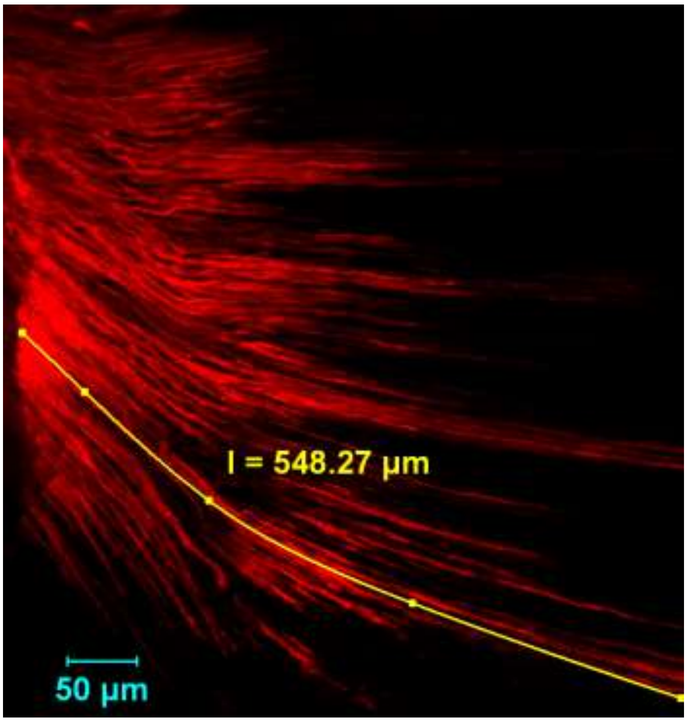
Figure 12: Penetration depth at cervical one - third

Groups	N	Mean	S.D.	S.E.	95% C.I.	Min.	Max	F-value	P-value*
Group I (C-points + BC Sealer)	20	548.63	54.24	12.13	523.24-574.02	427.38	657.88	0.986	0.404
Group II (C-points + AH Sealer)	20	515.75	83.95	18.77	476.46-555.04	340.93	652.58		
Group III (F3 GP + BC Sealer)	20	526.46	76.63	17.13	490.59-562.33	380.04	669.25		
Group IV (F3 GP + AH Sealer)	20	516.52	56.52	12.64	490.07-542.98	421.25	614.72		

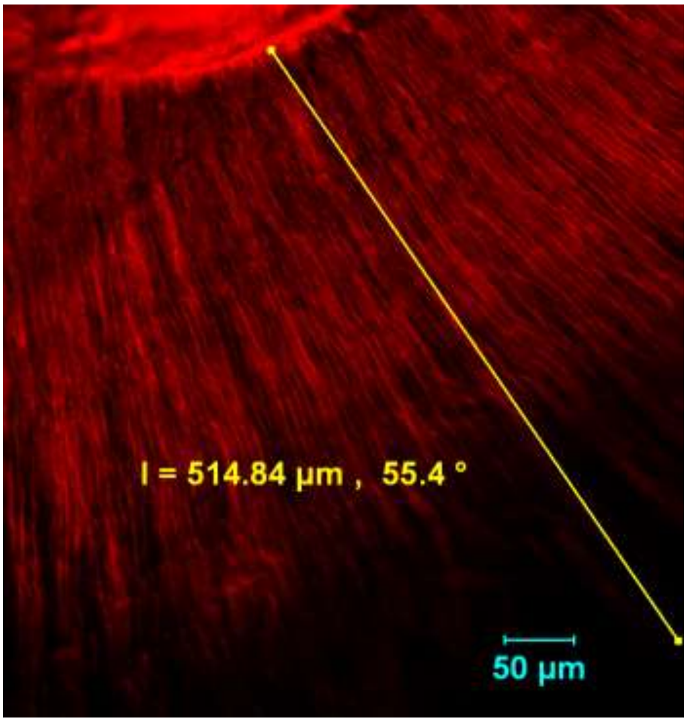
Table 3: Comparison of mean penetration depth among the four groups at middle one-third



Graph 3: Comparison of mean penetration depth among the four groups at middle one-third

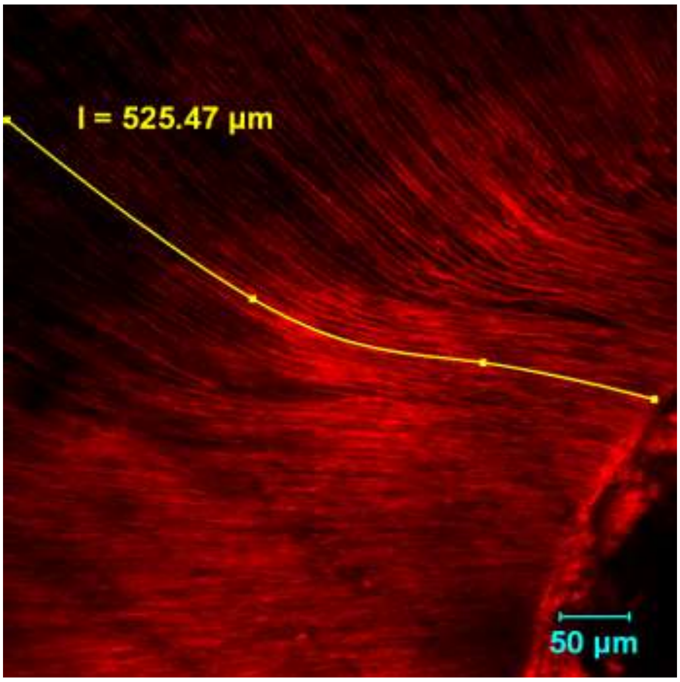


Group I- C Points + BC sealer

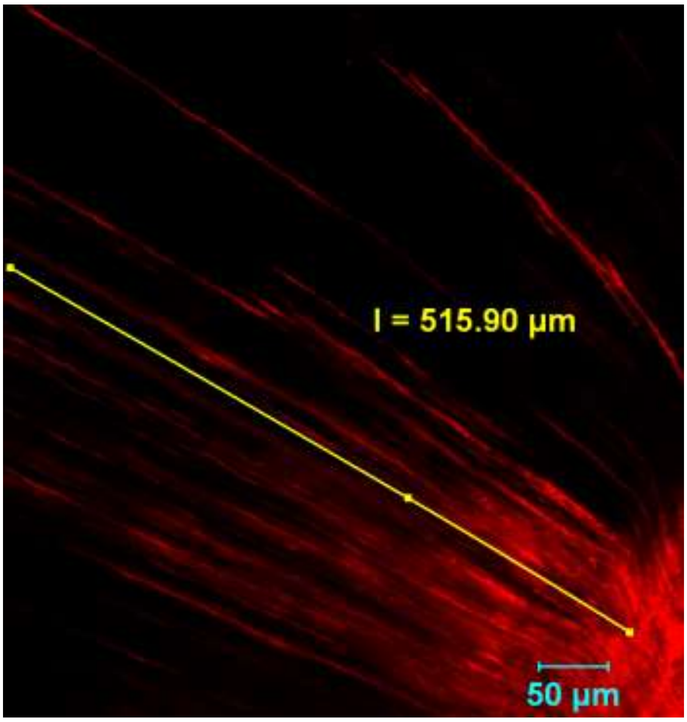


Group II- C Points + AH plus sealer

Penetration depth at middle one - third



Group III- F3 GP+ BC sealer

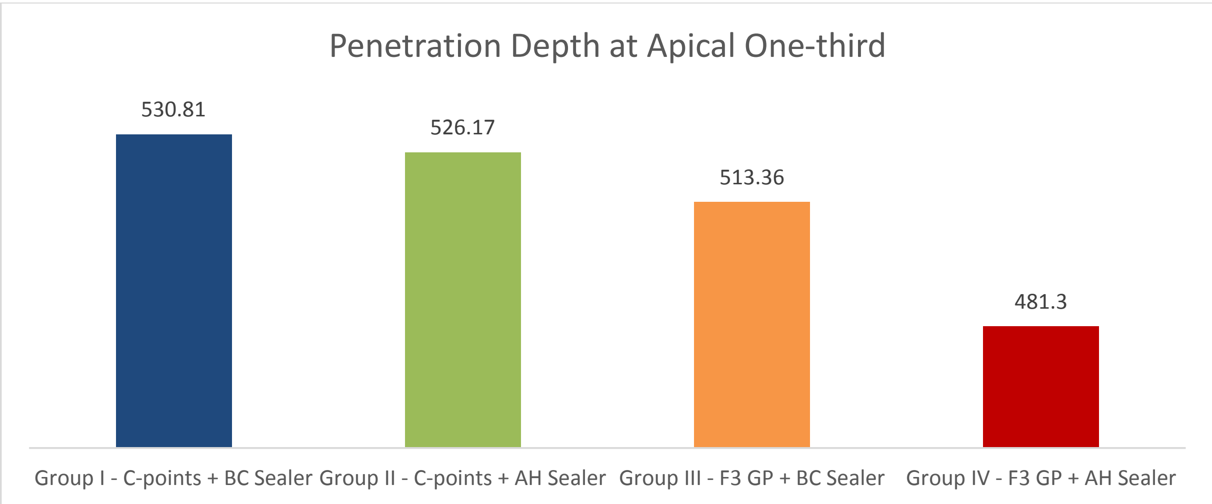


Group IV- F3 GP + AH plus sealer

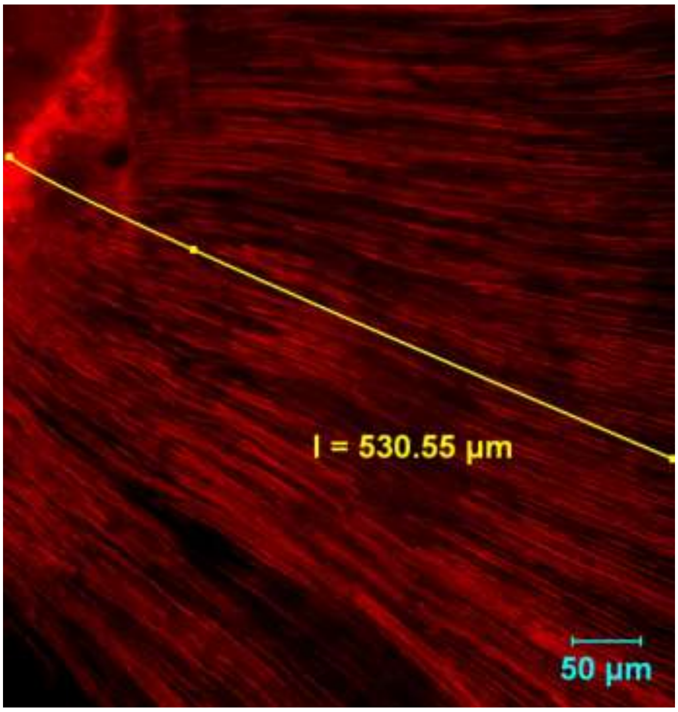
Figure 13: Penetration depth at middle one-third

Groups	N	Mean	S.D.	S.E.	95% C.I.	Min.	Max	F-value	P-value*
Group I (C-points + BC Sealer)	20	530.81	40.66	9.09	511.78-549.84	463.99	626.15	1.755	0.163
Group II (C-points + AH Sealer)	20	526.17	59.32	13.26	498.41-553.94	427.86	637.97		
Group III (F3 GP + BC Sealer)	20	513.36	55.69	12.45	487.30-539.43	446.01	618.31		
Group IV (F3 GP + AH Sealer)	20	481.30	120.19	26.87	425.04-537.55	152.95	638.49		

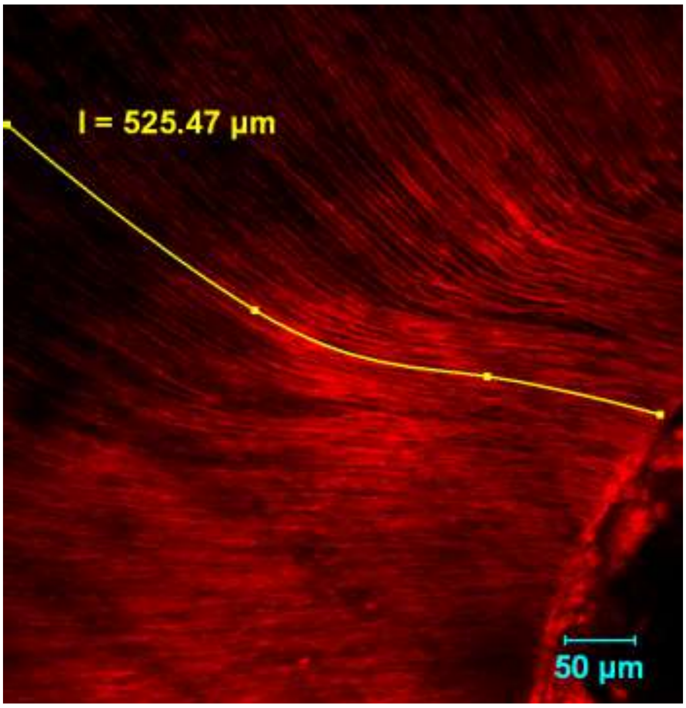
Table 4: Comparison of mean penetration depth among the four groups at apical one-third



Graph 4: Comparison of mean penetration depth among the four groups at apical one-third

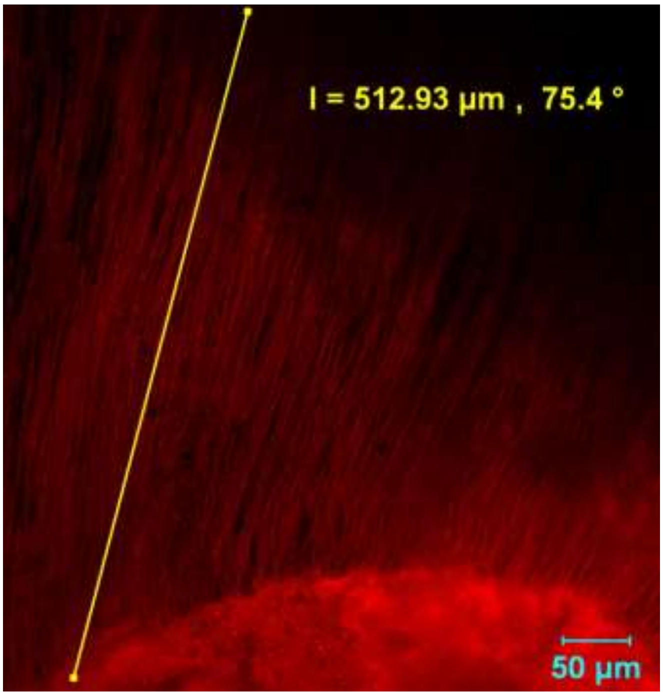


Group I- C Points + BC sealer

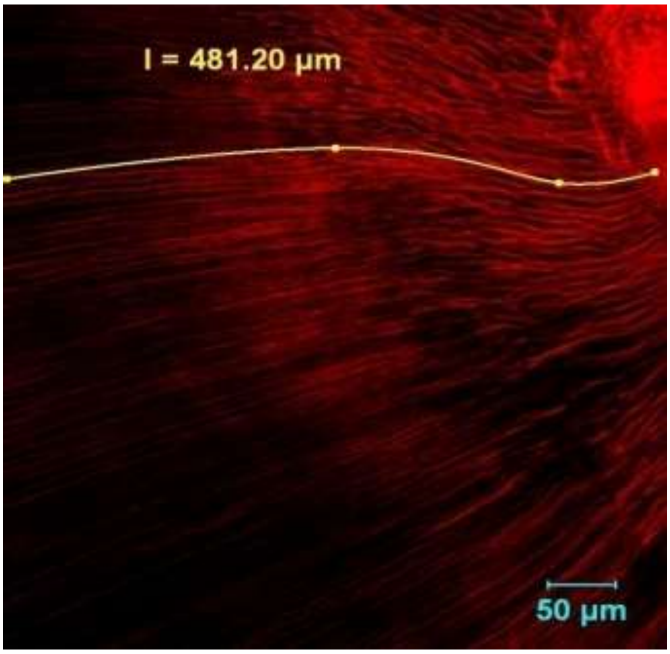


Group II- C Points + AH plus sealer

Penetration depth at apical one - third



Group III- F3 GP + BC sealer



Group IV- F3 GP + AH plus sealer

Figure 14: Penetration depth at apical one-third

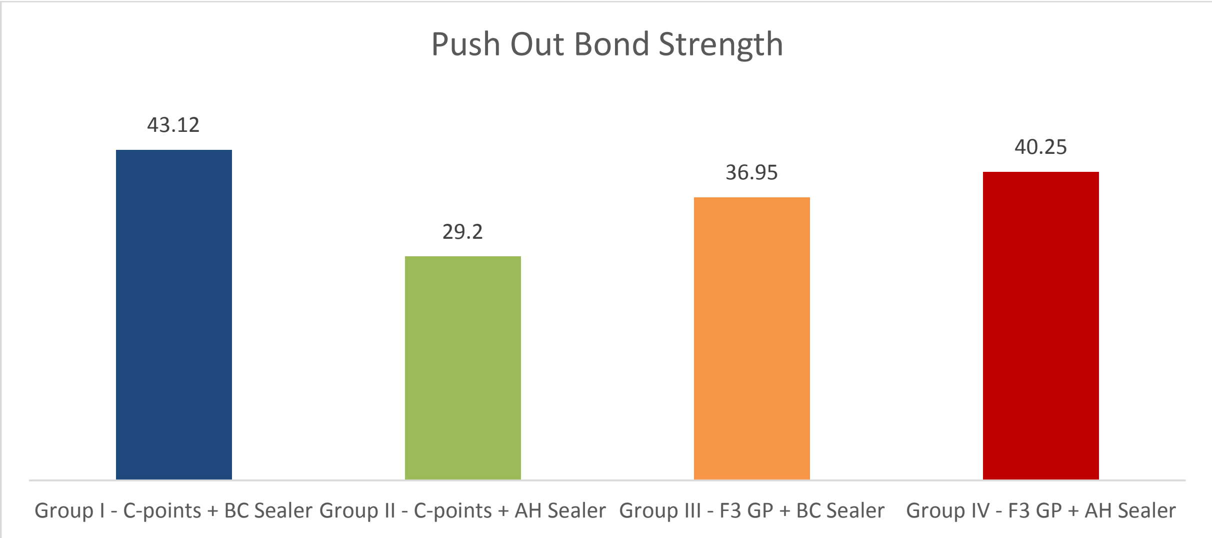
The results of the present study showed that there is no significant difference in the depth of penetration among four groups – Group I (C points with Bioceramic MTA Plus sealer), Group II (C points with AH plus sealer), Group III (Gutta percha with Bioceramic MTA Plus sealer) & Group IV (Gutta percha with AH plus sealer). Also, there is no significant difference among the coronal, middle & apical third of the root.

But Group I (C points with Bioceramic MTA Plus sealer) showed greater mean value (534.53) when compared to all the other groups. Group II & Group III showed greater mean value (524.87 & 509.14) when compared to Group IV. Group IV (Gutta Percha with AH Plus sealer)showed the lowest mean value of 503.89.

PUSH-OUT BOND STRENGTH

Groups	**N**	**Mean**	**S.D.**	**S.E.**	**95% C.I.**	**Min.**	**Max**	**F-value**	**P-value***
Group I (C-points + BC Sealer	60	43.12	23.59	3.04	37.02-49.21	8.42	102.55	5.221	0.002†
Group II (C-points + AH Sealer)	60	29.20	19.37	2.50	24.20-34.21	4.12	68.68		
Group III (F3 GP + BC Sealer)	60	36.95	24.22	3.12	30.70-43.21	8.61	134.93		
Group IV (F3 GP + AH Sealer)	60	40.25	11.80	1.52	37.20-43.30	20.58	67.18		

Table 5: Comparison of mean push out bond strength among the four groups



Graph 5: Comparison of mean push out bond strength among the four groups

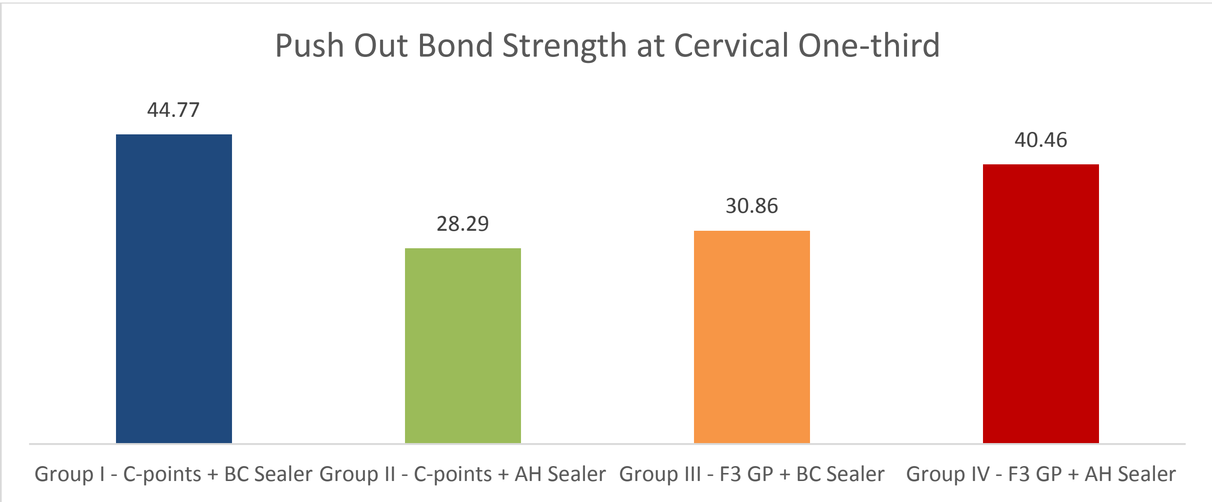
Groups	M.D.	95% C.I.	P-value*
Group I v/s Group II	13.91	4.29-23.53	0.001†
Group I v/s Group III	6.16	-3.45-15.78	0.348
Group I v/s Group IV	2.86	-6.75-12.48	0.867
Group II v/s Group III	-7.74	-17.36-1.86	0.161
Group II v/s Group IV	-11.04	-20.66--1.43	0.017†
Group III v/s Group IV	-3.29	-12.91-6.31	0.811

Group I (C-points + BC Sealer); Group II (C-points + AH Sealer); Group III (F3 GP + BC Sealer); Group IV (F3 GP + AH Sealer); *P-value derived from Tukey's HSD post hoc test; †significant at $p < 0.05$

Table 6: Pair wise comparison of mean push out bond strength between the groups

Groups	N	Mean	S.D.	S.E.	95% C.I.	Min.	Max	F-value	P-value*
Group I (C-points + BC Sealer	20	44.77	22.46	5.02	34.25-55.28	8.79	90.39	3.542	0.018
Group II (C-points + AH Sealer)	20	28.29	20.41	4.56	18.74-37.84	4.30	65.32		
Group III (F3 GP + BC Sealer)	20	30.86	17.96	4.01	22.46-39.27	8.61	66.81		
Group IV (F3 GP + AH Sealer)	20	40.46	11.41	2.55	35.11-45.80	21.89	65.76		

Table 7: Comparison of mean push out bond strength among the four groups at cervical one-third



Graph 6: Comparison of mean push out bond strength among the four groups at cervical one-third

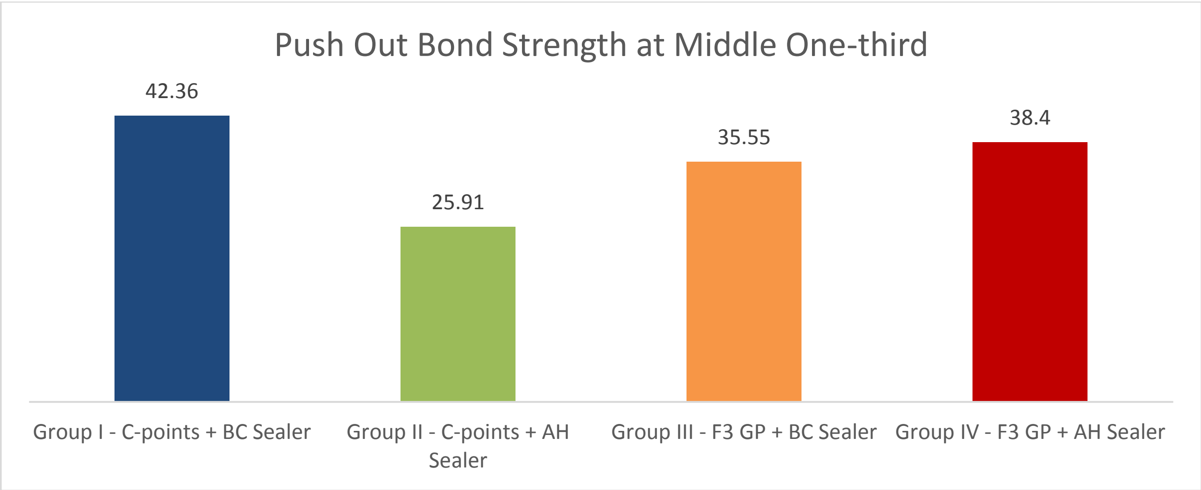
Groups	M.D.	95% C.I.	P-value*
Group I v/s Group II	16.47	1.07-31.87	0.031†
Group I v/s Group III	13.90	-1.49-29.30	0.091
Group I v/s Group IV	4.31	-11.08-19.70	0.883
Group II v/s Group III	-2.57	-17.96-12.82	0.972
Group II v/s Group IV	-12.16	-27.56-3.23	0.170
Group III v/s Group IV	-9.59	-24.99-5.80	0.364

Group I (C-points + BC Sealer); Group II (C-points + AH Sealer); Group III (F3 GP + BC Sealer); Group IV (F3 GP + AH Sealer); *P-value derived from Tukey's HSD post hoc test; †significant at $p < 0.05$

Table 8: Pair wise comparison of mean push out bond strength between the groups at cervical one-third

Groups	N	Mean	S.D.	S.E.	95% C.I.	Min.	Max	F-value	P-value*
Group I (C-points + BC Sealer)	20	42.36	25.98	5.80	30.20-54.52	8.42	90.57	1.989	0.123
Group II (C-points + AH Sealer)	20	25.91	19.11	4.27	16.97-34.86	4.12	68.68		
Group III (F3 GP + BC Sealer)	20	35.55	28.12	6.28	22.39-48.72	14.78	134.93		
Group IV (F3 GP + AH Sealer)	20	38.40	12.05	2.69	32.76-44.04	20.58	59.69		

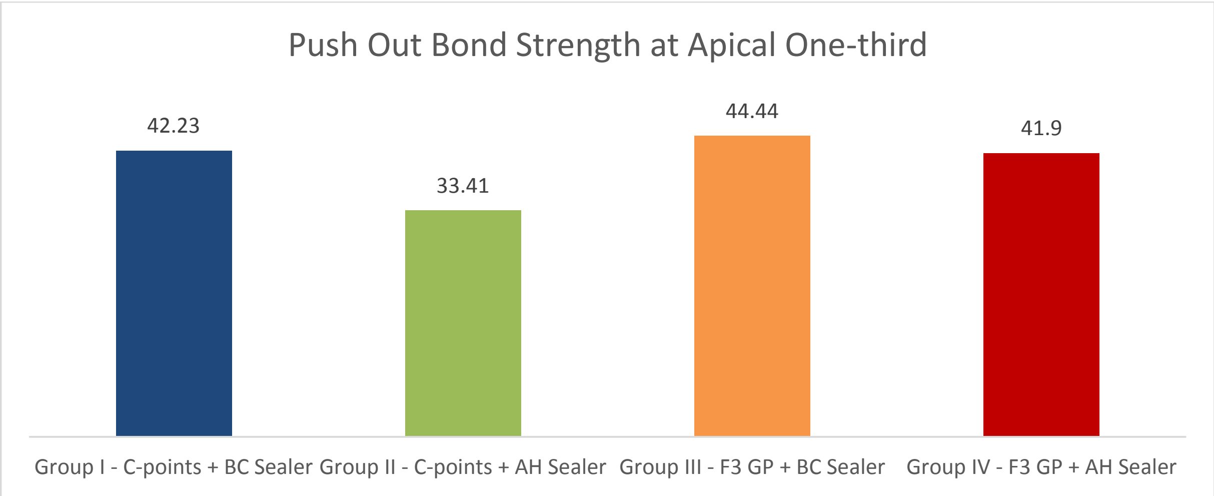
Table 9: Comparison of mean push out bond strength among the four groups at middle one-third



Graph 7: Comparison of mean push out bond strength among the four groups at middle one-third

Groups	N	Mean	S.D.	S.E.	95% C.I.	Min.	Max	F-value	P-value*
Group I (C-points + BC Sealer)	20	42.23	23.34	5.22	31.30-53.15	8.61	102.55	1.140	0.339
Group II (C-points + AH Sealer)	20	33.41	18.77	4.19	24.62-42.20	6.37	62.13		
Group III (F3 GP + BC Sealer)	20	44.44	24.65	5.51	32.90-55.98	8.80	107.78		
Group IV (F3 GP + AH Sealer)	20	41.90	12.27	2.74	36.16-47.65	25.26	67.18		

Table 10: Comparison of mean push out bond strength among the four groups at apical one-third



Graph 8: Comparison of mean push out bond strength among the four groups at apical one-third

The results of the present study showed that C points with Bioceramic MTA Plus sealer (Group I) had statistically significant higher bond strength than Group II (C points with AH plus sealer) in the coronal third. Except the above mentioned difference, there is no significant difference between other groups in any of the regions.

But Group I (C points with Bioceramic MTA Plus sealer) showed greater mean value (43.12) when compared to all the other groups. Group III & Group IV showed greater mean value (36.95 & 40.25) when compared to Group II. Group II (C Points with AH Plus sealer) showed the lowest mean value of 29.20.

DISCUSSION

Success of root canal treatment depends on the thorough debridement of the root canal system, destruction of pathogenic organisms and fluid tight sealing of the canal space[1]. Combination of the endodontic sealer & core material achieves the fluid tight seal. To minimize the leakage, sealer and core materials should form chemically bonded mass that should also bond to dentine[1].

The present study was done to compare & evaluate the penetration depth & push-out bond strength of Bioceramic **(** MTA Plus) & AH Plus sealer used with C points and guttapercha. Among the various core materials used, Gutta percha has been the standard obturation material for root canal therapy. Gutta percha possesses many properties such as biocompatibility, chemical stability, radiopacity, non porosity & the ability to manipulate . The main drawback of Gutta percha was its hydrophobic nature. Hence, the Gutta percha does not bond to the internal tooth structure, resulting in incomplete seal which results in bacterial microleakage[4]. The application of heat improves the better flow & adaptation of GP. But, on heat application, Gutta percha shrinks & leads to microleakage[4].

The C Point system is one of the newly introduced obturating materials. The system consists of a core material,"C Points" (also called as Propoints) that contains a central core with hydrophilic polymer coating which absorbs water from the root canal space and swells laterally against the canal wall leading to self-sealing[5]. Two-components are present in C Points , a hydrophilic polymer coating, which radially expands to seal the root canal & a central core which provides good handling characteristics by absorbing the naturally present moisture in the dentinal tubules and residual dihydrogen monoxide from the instrumented root canal space, C Points are designed to expand laterally without expanding axially. The inner core of the C Points is composed of two proprietary nylon polymers: Trogamid CX & Trogamid T. The polymer coating (copolymer of acrylo nitrile and vinyl pyrrolidone) was cross linked & polymerized by using allyl methacrylate & a thermal initiator [5].

Root canal filling with AH plus sealer and Gutta percha has gained popularity due to its biocompatibility, availability, radiopacity and easy to use. AH Plus is an epoxy-bis-phenol resin based sealer which also contains adamantine and bonds to root canal wall[26]. AH plus is a two-component paste/paste root canal sealer. AH plus sealer contains epoxy resin, it has greater adhesion to root dentin. AH Plus has better penetration into the micro irregularities because of its creep capacity and long setting time, which increases the mechanical interlocking between sealer and root dentin. But a study done by Pawar et al, showed that there was inadequate bonding between the sealer and the gutta-percha point, allowing leakage at this interface. Since it contains resin and has faster setting time, AH plus tends to shrink and cause early debonding from the root canal[26].

Mineral trioxide aggregate (MTA) has been widely used as a promising biomaterial for perforation repair, root end fillings, pulpotomies, and apexification procedures[9-11]. MTA is a bioactive material that can form a layer of hydroxyapatite or carbonated apatite on its surface when it comes in contact with a phosphate-containing fluid for 2 months. Formation of this interfacial layer develops a chemical bond between MTA and dentinal walls. MTA possess an effective sealing ability and marginal adaptation. Its retention characteristics increased from 24 to 72 hours, regardless of the presence of moisture which is 50% smaller than regular MTA and less than 1um.

The most important criteria of a root canal sealer is to fill the imperfections and to increase the adaptation of root filling materials to the canal walls. It should fill the irregularities and minor discrepancies between the core filling material and the root canal wall, assists in microbial control if microorganisms were left in the root canal walls or in the tubules & provides an impervious seal.[38]

The sealer penetration into the dentinal tubules is an important consideration while determining the efficacy of the root canal sealers. Penetration of sealer into the dentin increases the interface between dentin and material, thus improving the sealing ability. Sealer entombs residual bacteria within the dentinal tubules and the chemical components of the sealers might exert an antibacterial effect which will be enhanced by the closer approximation to bacteria. Thus, the outcome or success rate of endodontic therapy might be influenced by the depth of sealer penetration [12,21].

Although different tools are available for evaluation, CLSM was better in providing detailed information about the presence of sealer and its distribution inside the dentinal tubules[7]. CLSM utilizes the technology in which combination of physical- chemical principles, optical microscopy and computing resources are used for acquisition and processing of images[39-41]. The laser source was used for promoting excitation of fluorophores. The laser beams may diffuses through the enamel, dentin and biofilms, thus detects their inner structures and forms several two-dimensional images. In addition, it uses hard tissue or non-decalcified samples that do not require the specific sectioning technique (sputter coating)[36].

Regarding the penetration depth, the results of the present study showed that , there is no statistically significant difference between the groups. Mean values of penetration depth of Group I is slightly higher than other groups. It might be due to hydrophilic properties of C points[5] & hydrophilic nature of MTA plus sealer[25], which allows the C points to hydrate & swell to fill any voids, canal irregularities & pressing the hydrophilic sealer into dentinal tubules, lateral portals of exit & concavities of the root canal, which leads to improvement in bond strength in time. It also forms a nano-composite network of gel like calcium silicate hydrate intimately mixed with hydroxyapatite, creating hermetic seal when applied inside the root canal. It also produces calcium hydroxide & hydroxyapatite as by-products, which give exceptional dimensional stability & filling the anatomical gaps & potentially providing a better seal[9-11,42].

In this study, all the groups showed no statistical differences among coronal, middle & apical third of the root ($p > 0.05$; ANOVA-Tukey HSD).

Bond-strength assessment is a popular method used for assessment of the effectiveness of adhesion between tooth structure and endodontic materials. Various tests were used to measure bond strength such as push-out bond strength test, shear bond strength test and micro-tensile bond strength test. In shear testing, it is difficult to closely align the shear-loading device with the bonded interface. The load is offset at some distance from the bonded interface, resulting in unpredictable torque loading on the specimen. The tensile strength test is sensitive, in which small alterations in stress distribution or in the specimen application of load have a substantial influence on the results [43].

Push-out test is one of the most reliable & commonly used method. The conditions in the push-out test are comparable to clinical conditions, in which the tested items are directly placed within the prepared canals with normal tubular configuration and organization[44]. The test is based on the shear stress at the interface between cement and dentin, which is comparable with stresses under clinical conditions. The force application was in apico-coronal direction to avoid interference due to canal taper, during dislodgement of the filling material[45]. In all the samples, core material is used along with the sealers. Bond strength testing might not completely replicate the clinical performance of root canal sealers, but it still provides valuable information comparing different sealers or obturation materials[46].

In this study, the push-out test method was used to test the bond strengths of MTA plus & AH Plus sealer used with C points and gutta percha.

Except in the coronal third (where there is statistically significant difference between Group I and Group II), there is no statistically significant difference in the push out bond strength results among the groups in all the thirds of the root.

Group I showed higher mean values of bond strength than all other groups. As +mentioned earlier, this might be due to hydrophilic properties of both the obturating material and the sealer (C points & MTA plus sealer). Furthermore, the biomineralization process of MTA plus sealer enhances the resistance to dislodgement of MTA from the dentin, leading to better bond strength[47-49]. This might be due to the hydrophilic nature of both C points and MTA plus sealer. This is in accordance with the study done by vibha hegde et al, where both the hydrophilic core and sealer material exhibited greater sealing ability compared to hydrophobic obturating material.[4]

Group IV (AH plus / Gutta percha) also showed similar, but slightly lesser mean values than Group I and greater mean values of bond strength than Group II and Group III because of the ability of epoxy resin based sealers to penetrate into the micro irregularities due to its creep capacity and the formation of covalent bond by an epoxide ring to amine in collagen network, thus improving the bond strength[14].

Group II (C points / AH plus) showed the least bond strength values when compared to all other groups. The result of our study showed that AH plus performed better with hydrophobic GP than hydrophilic C points. This might be due to the non-adhesion between hydrophilic C points & hydrophobic AH sealer , inspite of the fact that AH plus performed better with both the GP and C points in terms of penetration depth. The above result is in accordance with the study done by Derya Deniz Sungur et al that the dentinal tubule penetration has minimal effect on adhesion ability and the better performance of the sealer depends not only on the penetration depth, but also on its bonding with the obturating core materials and dentin[33].

SUMMARY

The present study was done in the Department of Conservative dentistry and Endodontics, KSR Institute of Dental Science and Reaearch. The aim of the present study was to evaluate & compare the penetration depth & push out bond strength of Bioceramic & AH Plus sealer with C points and gutta percha. 80 mandibular premolar teeth were used & decoranated. All teeth were prepared using protaper rotary file system upto F3 file size using Xmart plus (DENTSPLY Maillefer). The irrigation solution used after each instrumentation were NaOCl, 17% EDTA & normal saline. Samples were grouped into four based on the core material & root canal sealer used of each group containing 20 number of teeth. In Group I, obturation done using C Points & MTA plus (bioceramic sealer); Group II – C Points & AH Plus sealer; Group III – Gutta Percha & MTA plus (bioceramic sealer) & Group IV – Gutta percha & AH Plus sealer. Horizontal sections of 2 mm thickness were made from coronal, middle & apical region of samples. Specimens were analysed using confocal laser scanning electron microscopy for the depth of penetration of sealers and the push out bond strength test was done with the help of universal testing machine at a cross head speed of 0.5 mm / min.

The findings of the present study can be summarized as follows:

Push out bond strength & penetration depth values were not significantly different between the tested groups, except between MTA plus sealer with C points & AH plus sealer with C points in the coronal third push-out bond strength.

Based on the mean values:

1. MTA plus sealer & AH plus sealer showed better depth of penetration when used with C points than with GP.
2. MTA plus sealer exhibited better bond strength with C Points and Gutta Percha. But, AH Plus performed better with Gutta Percha when compared with C Points.
3. Although AH plus sealer with C points showed better depth of penetration, it exhibited the least bond strength.

CONCLUSION

1. The present study showed that the depth of penetration can be directly correlated with the bond strength, but not with all sealers & core materials.

2. Within the limitations of this study, it can be concluded that Bioceramic (MTA plus) sealer with C points showed greater penetration depth & greater bond strength.

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To

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*****

Your dissertational study titled "COMPARATIVE EVALUATION OF PENETRATION DEPTH AND PUSH OUT BOND STRENGTH OF C POINTS AND GUTTA PERCHA USING BIOCERAMIC AND AH PLUS SEALER – AN IN VITRO STUDY" presented before the ethical committee on 15th Dec. 2015 has been discussed by the committee members and has been approved.

You are requested to adhere to the ICMR guidelines on Biomedical Research and follow good clinical practice. You are requested to inform the progress of work from time to time and submit a final report on the completion of study.

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This is to certify that this dissertation work titled "**Comparative evaluation of Penetration Depth & Push-out Bond Strength of C Points & Gutta percha using Bioceramic sealer & AH plus sealer- an invitro study"** of the candidate **Dr.M.Loganathan** with registration number**241517402** for the award of "**Master of Dental Surgery"** in the branch of **Conservative Dentistry and Endodontics**. I personally verified the urkund.com website for the purpose of plagiarism Check. I found that the uploaded thesis file contains from introduction to conclusion pages and result shows **2 %** percentage of plagiarism in the dissertation.

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